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(54) A MODULATOR FOR RADAR TRANSMITTERS

(71) We, THOMSON-CSF, a French Body Corporate, of 173, Boulevard Haussmann, 75008 Paris - France, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

The present invention relates to a variable pulse-length modulator, in particular for radar transmitters, and to a radar incorporating such a modulator.

The modulators currently used in radars which employ pulsed emission may be divided into three main categories.

Modulators which are known as vacuum tube modulators employ a triode or tetrode tube as their switching means. Such modulators allow pulses of continuously variable length to be generated, or a large number of pulses of differing duration. The low internal impedance of such devices enables them to be matched to loads of various kinds. However, such modulators have the drawbacks of high weight and volume and poor reliability. In addition, the presence of a storage capacitor and the high level of the high tension employed in devices of this kind make it necessary to provide careful safeguards both for the equipment and the personnel using it.

Delay line modulators, because of the lower voltages employed, are of more reasonable dimensions, weight, volume and cost.

However, the capacity which such modulators have for adaptation to situations where varying pulse lengths and/or operating impedances are required is much more limited. What is more, with a delay line of acceptable size the shape of the pulses is much less satisfactory than from a vacuum-tube modulator.

Magnetic modulators in which energy is stored in an inductance carrying a large DC current and is then released by interrupting this current, have the disadvantages that the pulse produced is unstable with time and that their efficiency is poor because of the conditions under which the inductance is charged.

The present invention seeks to avoid the above mentioned disadvantages.

One object of the present invention is to provide a modulator which is extremely versatile as regards the duration of the signal or pulses which it delivers, the pulses being capable of emission in bursts or in a predetermined sequence.

Another object of the present invention is to provide a highly reliable modulator of small size.

A third object of the invention is to provide a modulator which delivers pulses of variable duration whose stability is comparable with that of the pulses delivered by vacuum-tube modulators.

The present invention consists in a modulator for a transmitter including a high voltage supply source, a separating circuit having an input and an output, a pulse generating circuit coupled by a coupling circuit to a transmission tube which forms said transmitter, said input being connected to said high voltage supply source and said output being connected to said pulse generating circuit wherein said pulse generating circuit further comprises a control device and a plurality of elementary delay cells of predetermined delay and which are individually switchable, said elementary delay cells each being connected to the coupling circuit of the tube by means of at least one switching circuit, said elementary delay cells being connected in series and isolated from one another by said at least one switching circuit, each switching circuit having a triggering electrode connected to said control device which emits triggering signals in sequence at different predetermined times enabling thus, by means of said individual cells, a resultant signal to be generated which is made up of

elementary pulses of predetermined length each corresponding to the delay from one of the elementary cells.

Such modulators may be used in particular in the transmitters of radars which employ pulsed emission in linear accelerators, or in laser emission devices.

The invention will be better understood from the following description and the accompanying drawings, in which:

Figure 1 is a block diagram of one embodiment of a modulator according to the present invention,

Figure 2 shows a detail of the embodiment of the invention as illustrated in Figure 1,

Figure 3 shows another particular embodiment of the subject of the invention.

Figure 4 shows a detail of the apparatus which is the subject of the invention

In Figure 1, the modulator which is the subject of the present invention has a high-tension supply source 1, which is connected to a pulse generated circuit 3 via separating circuit 2. The separating circuit 2 is, for example, formed in conventional fashion by a doubler inductance connected in series with a diode which provides protection for the supply source when pulses are generated by circuit 3. The pulse generating circuit 3 is coupled to a microwave transmitting tube 5, in the case of a radar for example, via a coupling circuit 4 such as a transformer.

In accordance with the invention, the pulse generating circuit 3 consists of a plurality of elementary, switchable delay cells 61 to 6n which are each capable of contributing towards the generation of a resultant signal made up of elementary pulses of lengths $\tau 1$ to τn, each corresponding to the delay from one of the elementary cells. The elementary delay cells, which are individually switchable and are connected in series are each connected to the coupling circuit 4 by at least one switching circuit 71 to 7n.

The switching circuits 71 to 7n have their triggering electrodes connected to outputs 81 to 8n of a control circuit 8. The control circuit 8 consists of a selecting register (not shown) which enables to select the times of triggering of each of the switching circuits 71 to 7n in relation to the radar repetition signal. For this purpose, the control circuit 8 emits triggering signals from each of its outputs 81 to 8n at different predetermined times in the repetition cycle of the radar, as dictated by the choice made at the selecting register.

The triggering of the switching circuits at the said predetermined times in the radar repetition cycle enables a succession of elementary pulses of length $\tau 1$ to τn to be generated, or when the times at which the successive elementary pulses are triggered coincide with the ends of the preceding pulse, a single pulse whose length is equal to the sum of the length of the selected individual pulses.

The circuit of Figure 2, the apparatus which is the subject of the present invention contains three elementary delay cells 61, 62, 63 which each represent a predetermined delay and which enable a resulting signal to be generated which is made up of elementary pulses of lengths $\tau 1$, $\tau 2$, $\tau 3$. The elementary cells 61, 62, 63 are connected in series and are isolated from one another by switching circuits 72, 73. Each elementary delay cell is connected to the coupling circuit 4 formed by a transformer by means of at least one switching circuit 71, 72, 73 whose triggering electrode is connected to an output 81, 82, 83 of the control circuit 8. The switching circuits are advantageously formed by thyristors. Diodes 92, 93 which are connected in anti-parallel to the thyristors 72, 73 enable the circuits for charging the capacitors in the elementary delay cells to be closed. By triggering the switching means or thyristors 71, or 71 and 72, or 71 and 72 and 73, it is possible to produce resulting signals of lengths $\tau 1$, $\tau 1 + \tau 2$, $\tau 1 + \tau 2 + \tau 3$ respectively. These pulses are spaced apart by one repitition period of the radar but with the possibility of a slight variation in the latter about its mean value.

When only one elementary cell is in use, the adjacent switching circuit is subject to a considerable variation in voltage because of the triggering of the neighbouring switching circuit. Capacitors connected to the terminals of the switching circuits enable the size of this variation in voltage to be limited.

In Figure 3 the thyristors which link the elementary cells connected in series, as shown in Figure 2, are replaced by a winding wound on a saturable magnetic core 472, 473. The control windings for these magnetic cores are connected to outputs 82, 83 of the control circuit 8.

In the saturated state the inductance of this member is close to the normal value of the inductance of a section of line. In the unsaturated state the member is of a high inductance, several hundreds of times greater than it inductance in the saturated state, and isolates the sections of line from one another. The operation of the modulator shown in Figure 3 is similar to that of the modulator shown in Figure 2.

If a resistance/capacitance peak-clipping circuit is employed with the foregoing pieces of apparatus it enables the pulses to be shaped and also allows the instability waves which appear in the resulting signal and which are caused by the summing of the individual pulses to be suppressed. The peak-clipping circuit also ensures that the characteristics of the resultant emitted signal are highly stable.

The peak-clipping circuit which is shown in

Figure 4 consists of a diode 51 connected in series with a capacitor 52 and a resistors 53 connected in parallel. The peak-clipping circuit is preferably connected in parallel between the output terminals of the coupling 4, i.e. the secondary terminals of the transformer 4.

The arrangements described above allow the number of circuits and their size to be optimised for a given peak transmission power. By way of example, the modes usable for transmission may consist of a mode number one where the pulse length is τ and the repetition frequency FR in one transmission cycle, a mode number two where the pulse length is 3τ and the repetition frequency $\frac{FR}{3}$, and a mode number three where the pulse length is 6τ and repetition frequency $\frac{FR}{6}$.

It is also possible to produce, for example, a general layout consisting of two modulators in parallel, the first having two elementary delay cells in series corresponding to pulses of length τ and 2τ, and the second containing two elementary cells in series corresponding to pulses of identical length 4τ.

In this case the following combinations can be obtained: τ, 4τ; τ, 8τ; 3τ, 4τ; 3τ, 8τ by coding and τ, 3τ, 4τ, 5τ, 7τ, 8τ, 9τ, 11τ in normal repetition cycles.

The size parameters then become : 4NTh, 4NT, 2NM.

It can be seen that versatility in use is achieved by using an arrangement according to the invention.

There has thus been described a modulator which allows ease of operation and a gain in size which previously could only be contemplated with the help of heavy, expensive and somewhat unreliable pieces of equipment.

WHAT WE CLAIM IS:-

1. A modulator for a transmitter including a high voltage supply source, a separating circuit having an input and an output, a pulse generating circuit coupled by a coupling circuit to a transmission tube which forms said transmitter, said input being connected to said high voltage supply source and said output being connected to said pulse generating circuit wherein said pulse generating circuit further comprises a control device and a plurality of elementary delay cells of predetermined delay and which are individually switchable, said elementary delay cells each being connected to the coupling circuit of the tube by means of at least one switching circuit, said elementary delay cells being connected in series and isolated from one another by said at least one switching circuit, each switching circuit having a triggering eleectrode connected to said control device which emits triggering signals in sequence at different predetermined times enabling thus, by means of said individual cells, a resultant signal to be generated which is made up of elementary pulses of predetermined length each corresponding to the delay from one of the elementary cells.

2. A modulator according to claim 1, wherein said at least one switching circuit is formed by a thyristor and a diode connected in anti parallel.

3. A modulator according to claim 1, wherein said at least one switching circuit isolating said cells connected in series is formed by windings wound on to a saturable magnetic core.

4. Modulators for radar transmitters substantially as hereinbefore described with reference to Figure 1, or Figure 2 or Figure 3 of the accompanying drawings.

5. A radar transmitter including a modulator as claimed in any of the preceding claims.

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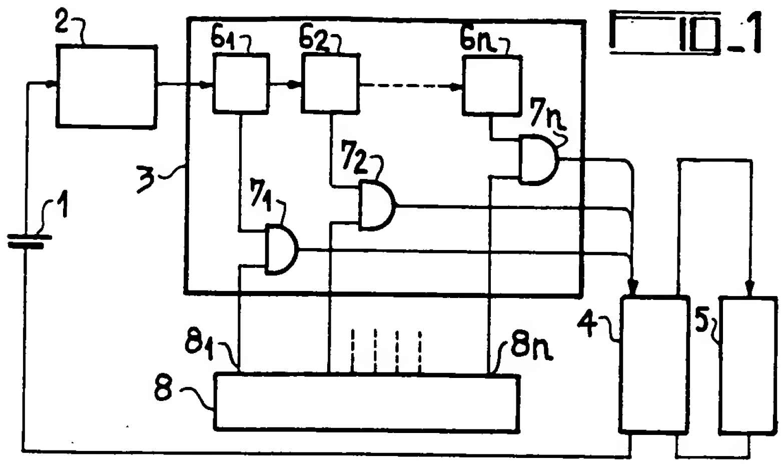
FIG_1



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2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

FIG_2

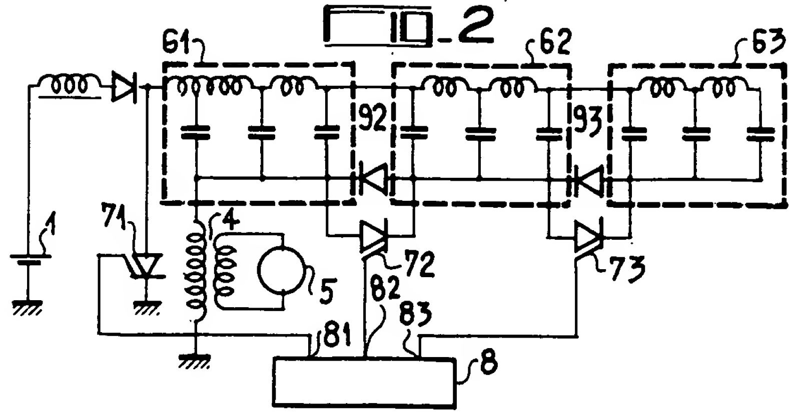

FIG_3

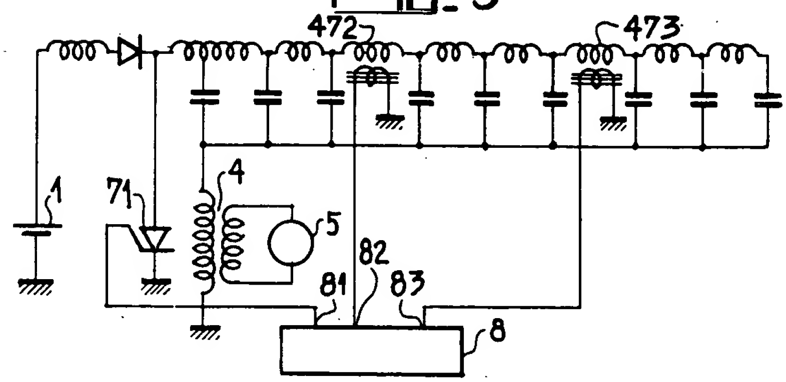

FIG_4